Package ‘StreamMetabolism’

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Type Package

Title Stream Metabolism-A package for calculating single station metabolism from diurnal Oxygen curves

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Depends zoo, chron, maptools

Description This package contains functions for calculating GPP, NDM,and R from single station diurnal Oxygen curves

License GPL (>= 3)

LazyLoad yes

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R topics documented:

`SteamMetabolism-package`

Functions for Calculating Stream Metabolism

Description

Calculate all of the pieces of stream metabolism and rolls it all into one function for convience-Calculate Stream Ecosystem Metabolism

Author(s)

Stephen A Sefick Jr <ssefick@gmail.com>

References

Odum, H. T. (1956). "Primary production in flowing waters." Limnology and Oceanography, 1: 102-117.

Bott, T.L. 1996. Primary Productivity and community respiration. In F. R. Hauer and G. A. Lamberti (ed.), Methods in stream ecology. Academic Press, Inc., New York, N.Y.

APHA (2005). Standard Methods for the Examination of Water and Wastewater. 21st Edition. Eds: Eaton, A.D., L.S. Clesceri, E.W. Rice and A. E. Greenberg. Washington D.C., published jointly by the American Public Health Association, the American Water Works Association and the Water Environment Federation.

Thyssen, N., Erlandsen, M., Jeppesen, E., Holm T. F.,1983. Modelling the reaeration capacity of low-land streams

O'Connor, D. J., and W. E. Dobbins (1958). Mechanisms of reaeration in natural streams. Transactions of American Society of Civil Engineers, 123: 641-666.

Stephens, D.W., and Jennings, M.E., 1976, Determination of primary productivity and community metabolism in streams and lakes using diel oxygen measurements: U.S. Geological Survey Computer Contribution, 100 p.

M.R. Grace and S.J. Imberger. 2006. "Stream Metabolism: Performing & Interpreting Measurements". Water Studies Centre Monash University, Murray Darling Basin Commission and New South Wales Department of Environment and Climate Change. 204 pp. Accessed at http://www.sci.monash.edu.au/wsc/docs/t
manual-v3.pdf

See Also

cfs.lps, Cs, contiguous.zoo, dC.dt, DOTemp,EcosystemProduction, EcosystemProduction.20, fmt.chron, Kt, lps.cfs, lps.cms, ODobbins, rear.flux, read.production, simp, sunrise.set, window.chron

Examples

```
##see help pages for all of the other functions
```

---

cfs.lps — *Convert from cubic feet per second to liters per second*

Description

Convert from cubic feet persecond to liters per second

Usage

```
cfs.lps(x)
```

Arguments

x	Discharge in cfs

Author(s)

Stephen A Sefick Jr.

---

contiguous.zoo — *contiguous.zoo*

Description

find continuous non NA portions of zoo time series data

Usage

```
contiguous.zoo(x)
```

Arguments

x	zoo time series object whatever indexes you want

Details

if you want to just find the contiguous portions of just one signal and not the interaction between two just duplicate the signal contiguous.zoo(data.frame(x, coredata(x))) should give you what you want

Value

data frame constiting of

`start`	start index
`end`	end index
`lengths`	length of record
`value`	logical stating whether a continuous string of non-NA values

Author(s)

Gabor Grothendieck and Stephen A Sefick Jr.

`Cs` *Saturation Concentration at temp*

Description

Calculates the concentration(mg/L) @ 100

Usage

```
Cs(x)
```

Arguments

`x`	Temperature in Degrees Celcius

Details

enter one temperature or a zoo time series of temperature

Value

single value or time series of mg/L@saturation for that temperature

Author(s)

Stephen A Sefick Jr.

References

APHA (2005). Standard Methods for the Examination of Water and Wastewater. 21st Edition. Eds: Eaton, A.D., L.S. Clesceri, E.W. Rice and A. E. Greenberg. Washington D.C., published jointly by the American Public Health Association, the American Water Works Association and the Water Environment Federation.

Examples

```
#single temperature
temp <- sample(20:30, 1)
Cs(temp)

#USGS Data (DOTemp)
library(chron)
library(zoo)
data(DOTemp)
Cs(DOTemp[,1])
```

---

dC.dt *Change in Oxygen per time step*

Description

Calculate the rate of change of Dissolved Oxygen

Usage

```
dC.dt(x)
```

Arguments

x	Dissolved Oxygen time series

Details

input zoo series takes the difference of DOt+1 - DOt

Value

zoo series of Dissolved Oxygen Differences with an NA for the first value as there is no value before that to subtract

Author(s)

Stephen A Sefick Jr.

References

Odum, H. T. (1956). "Primary production in flowing waters." Limnology and Oceanography, 1: 102-117.

Examples

```
data(DOTemp)
Diffconc <- dC.dt(DOTemp[,2])
plot(Diffconc)
```

DOTemp *Rhode River Street Pier–Maryland data set*

Description

Test data set from Stephens and Jennings SWProd calculator (USGS). The data has been interpolated to make it have readings every fifteen minutes.

Usage

```
data(DOTemp)
```

Format

DateTime DateTime

Temp Temperature in Celcius

DO Dissolved Oxygen

Details

This is only for example and should be used judiciously for any kind of ecosystem interpretation (requires zoo and chron packages).

Source

Stephens, D.W., and Jennings, M.E., 1976, Determination of primary productivity and community metabolism in streams and lakes using diel oxygen measurements: U.S. Geological Survey Computer Contribution, 100 p.

EcosystemProduction — *Calculate Ecosystem Production with the Single Station Method*

Description

Calculates Ecosytem Production

Usage

```
EcosystemProduction(velocity, meandepth, temperature, DO, day,
startday, endday, sunrise.time, sunset.time, num.readings)
```

Arguments

`velocity`	velocity in meters/s
`meandepth`	mean stream channel depth in meters
`temperature`	temperature in degrees Celcius
`DO`	Dissolved Oxygen in mg/L
`day`	date of the day of interest must be in quotes
`startday`	time of the start of the "day" usually 00:00:00 must be in quotes
`endday`	time of the end of the "day" usually 23:45:00 must be in quotes
`sunrise.time`	time of sunrise in the form 04:22:00 must be in quotes
`sunset.time`	time of sunset in the form 19:23:00 must be in quotes
`num.readings`	number of readings if data is collected in 15min intervals then there are 96 readings per day

Details

O'Conner Dobbins eauation is used to calculate Rearation coefficient. This function has only been tested with zoo objects read in with the read.production function. Should work for others, but untested. The values that are returned are only as good as the assumptions that went into collecting the data and should be viewed with scrutiny. Also the Reaeration coefficient is the most important number used in the calculation of Production and therefore needs to be as correct as possible. In the future (as the need arises- or enough requests come in) I plan on incorperating different ways of calculating this, but for now you are stuck with my assumptions for the task at hand.

Value

`CR24`	Community Repiration 24hours (sum of pre-dawn and post-dusk change in Oxygen curve corrected for Reaeration)
`NDM`	Net Daily Metabolism (sum of total day change in Oxygen Curve corrected for Reaeration)
`abs.CR24`	absolute value of Community Repiration 24hours (because CR24 is always negative)

GPP	Gross Primary Productivity=NDM+abs.CR24
P.R	P/R ratio
Units	areal units (gOxygen/squared meter/day) of everything except P.R which is unitless

Author(s)

Stephen A Sefick Jr.

References

Odum, H. T. (1956). "Primary production in flowing waters." Limnology and Oceanography, 1: 102-117.

M.R. Grace and S.J. Imberger. 2006. "Stream Metabolism: Performing & Interpreting Measurements". Water Studies Centre Monash University, Murray Darling Basin Commission and New South Wales Department of Environment and Climate Change. 204 pp. Accessed at http://www.sci.monash.edu.au/wsc/docs/t
manual-v3.pdf

Examples

```
#zoo real data
#velocity 0.6
#depth 0.4572
#sunrise 6:00AM
#sunset 8:15PM
#96 is the number of intervals in a day for fifteen minute data
data(DOTemp)
prod <- EcosystemProduction(0.6, 0.4572,
DOTemp[,1],
DOTemp[,2], "8/18/70", "00:00:00", "23:45:00", "06:00:00", "20:15:00", 96)
prod
```

EcosystemProduction.20 *Calculate Ecosystem Production with the Single Station Method With Temperature Correction (Thyssen) for Respiration. In other words average night time respiration is corrected for the change in temperature for the day from the average temperature for the night.*

Description

Calculates Ecosytem Production with respiration corrected for temperature.

Usage

```
EcosystemProduction.20(velocity, meandepth, temperature, DO, day,
startday, endday, sunrise.time, sunset.time, num.readings)
```

Arguments

`velocity`	velocity in meters/s
`meandepth`	mean stream channel depth in meters
`temperature`	temperature in degrees Celcius
`DO`	Dissolved Oxygen in mg/L
`day`	date of the day of interest must be in quotes
`startday`	time of the start of the "day" usually 00:00:00 must be in quotes
`endday`	time of the end of the "day" usually 23:45:00 must be in quotes
`sunrise.time`	time of sunrise in the form 04:22:00 must be in quotes
`sunset.time`	time of sunset in the form 19:23:00 must be in quotes
`num.readings`	number of readings if data is collected in 15min intervals then there are 96 readings per day

Details

The only difference between this function and EcosystemProduction is the correction for temperature for respiration. I think EcosystemProduction.20 (The function documented in this page) should be favoured over just EcosystemProduction because of it should better estimate Metabolism.

O'Conner Dobbins eauation is used to calculate Rearation coefficient. This function has only been tested with zoo objects read in with the read.production function. Should work for others, but untested. The values that are returned are only as good as the assumptions that went into collecting the data and should be viewed with scrutiny. Also the Reaeration coefficient is the most important number used in the calculation of Production and therefore needs to be as correct as possible. In the future (as the need arises- or enough requests come in) I plan on incorperating different ways of calculating this, but for now you are stuck with my assumptions for the task at hand.

Value

`CR24`	Community Repiration 24hours (sum of pre-dawn and post-dusk change in Oxygen curve corrected for Reaeration)
`NDM`	Net Daily Metabolism (sum of total day change in Oxygen Curve corrected for Reaeration)
`abs.CR24`	absolute value of Community Repiration 24hours (because CR24 is always negative)
`GPP`	Gross Primary Productivity=NDM+abs.CR24
`P.R`	P/R ratio
`Units`	areal units (gOxygen/squared meter/day) of everything except P.R which is unitless

Author(s)

Stephen A Sefick Jr.

References

Odum, H. T. (1956). "Primary production in flowing waters." Limnology and Oceanography, 1: 102-117.

Thyssen, N., Erlandsen, M., Jeppesen, E., Holm T. F.,1983. Modelling the reaeration capacity of low-land streams

M.R. Grace and S.J. Imberger. 2006. "Stream Metabolism: Performing & Interpreting Measurements". Water Studies Centre Monash University, Murray Darling Basin Commission and New South Wales Department of Environment and Climate Change. 204 pp. Accessed at http://www.sci.monash.edu.au/wsc/docs/t manual-v3.pdf

Examples

```
#zoo real data
#velocity 0.6
#depth 0.4572
#sunrise 6:00AM
#sunset 8:15PM
#96 is the number of intervals in a day for fifteen minute data
data(DOTemp)
prod.20 <- EcosystemProduction.20(0.6, 0.4572, DOTemp[,1],
DOTemp[,2], "8/18/70", "00:00:00",
"23:45:00", "06:00:00", "20:15:00", 96)
prod.20

#compare to EcosystemProduction
prod <- EcosystemProduction(0.6, 0.4572, DOTemp[,1],
DOTemp[,2], "8/18/70", "00:00:00",
"23:45:00", "06:00:00", "20:15:00", 96)

#notice that NDM stays the same...#
prod
prod.20
```

`EcosystemProduction.K` *Calculate Ecosystem Production with the Single Station Method With Temperature Correction (Thyssen) for Respiration. In other words average night time respiration is corrected for the change in temperature for the day from the average temperature for the night.*

Description

You get to provide the rearation rate K

Usage

```
EcosystemProduction.K(K, meandepth, temperature, DO, day, startday = 00:00:00, endday = 23:45:00, sunri
```

Arguments

`K`	Calculated or Measured Rearation `K`
`meandepth`	mean stream channel depth in meters
`temperature`	Time Series temperature in degrees Celcius
`DO`	Time Series Dissolved Oxygen in mg/L
`day`	date of the day of interest must be in quotes
`startday`	time of the start of the "day" usually 00:00:00 must be in quotes
`endday`	time of the end of the "day" usually 23:45:00 must be in quotes
`sunrise.time`	time of sunrise in the form 04:22:00 must be in quotes
`sunset.time`	time of sunset in the form 19:23:00 must be in quotes
`num.readings`	number of readings if data is collected in 15min intervals then there are 96 readings per day

Details

**The only difference between this function and EcosystemProduction.20 is you supply K.

This function has only been tested with zoo objects read in with the read.production function. Should work for others, but untested. The values that are returned are only as good as the assumptions that went into collecting the data and should be viewed with scrutiny. Also the Reaeration coefficient is the most important number used in the calculation of Production and therefore needs to be as correct as possible.

Value

`CR24`	Community Repiration 24hours (sum of pre-dawn and post-dusk change in Oxygen curve corrected for Reaeration)
`NDM`	Net Daily Metabolism (sum of total day change in Oxygen Curve corrected for Reaeration)
`abs.CR24`	absolute value of Community Repiration 24hours (because CR24 is always negative)
`GPP`	Gross Primary Productivity=NDM+abs.CR24
`P.R`	P/R ratio
`Units`	areal units (gOxygen/squared meter/day) of everything except P.R which is unitless

Author(s)

Stephen A Sefick Jr.

References

Odum, H. T. (1956). "Primary production in flowing waters." Limnology and Oceanography, 1: 102-117.

Thyssen, N., Erlandsen, M., Jeppesen, E., Holm T. F.,1983. Modelling the reaeration capacity of low-land streams

M.R. Grace and S.J. Imberger. 2006. "Stream Metabolism: Performing & Interpreting Measurements". Water Studies Centre Monash University, Murray Darling Basin Commission and New South Wales Department of Environment and Climate Change. 204 pp. Accessed at http://www.sci.monash.edu.au/wsc/docs/t manual-v3.pdf

Examples

```
#zoo real data
#velocity 0.6
#depth 0.4572
#sunrise 6:00AM
#sunset 8:15PM
#96 is the number of intervals in a day for fifteen minute data
data(DOTemp)

K <- ODobbins(0.6, 0.4572)
prod.K <- EcosystemProduction.K(K, 0.4572, DOTemp[,1],
DOTemp[,2], "8/18/70", "00:00:00",
"23:45:00", "06:00:00", "20:15:00", 96)
prod.K

#compare to EcosystemProduction.20
prod.20 <- EcosystemProduction.20(0.6, 0.4572,
DOTemp[,1],
DOTemp[,2], "8/18/70", "00:00:00",
"23:45:00", "06:00:00", "20:15:00", 96)


prod.K
prod.20
```

---

fmt.chron *Format Dates*

Description

Used in the FUN argument of read.zoo for dates in the format mm/dd/yyyy hh:mm:ss

Usage

```
fmt.chron(x)
```

Arguments

`x`	Data Time Column

Details

used internally in read.production

Author(s)

Stephen A Sefick Jr

See Also

`read.production`

`Kt` *Temperature Correction For Reaeration Value*

Description

Temperature Correction For Reaeration Value

Usage

```
Kt(K, temp)
```

Arguments

`K`	Rearation Coefficient single value or in a zoo object
`temp`	temperature value at time t in Degrees Celcius

Value

Single Values or zoo series

Author(s)

Stephen A Sefick Jr

References

Thyssen, N., Erlandsen, M., Jeppesen, E., Holm T. F.,1983. Modelling the reaeration capacity of low-land streams

Examples

```
#data USGS
data(DOTemp)
#velocity 0.6, depth 0.4572
d <- ODobbins(0.6, 0.4572)
Kcorr <- Kt(d , DOTemp[,1])
```

---

lps.cfs *Liters Per Second to Cubic Feet per Second*

Description

Convience Function for converting from liters per second to cubic feet per second

Usage

```
lps.cfs(x)
```

Arguments

x	Discharge in Liters per Second

Value

Discharge in Cubic feet per second

Author(s)

Stephen A Sefick Jr

Examples

```
lps.cfs(134000)
```

---

lps.cms *Liters per second to cubic meters per second*

Description

Conversion Function

Usage

```
lps.cms(x)
```

Arguments

`x`	discharge in Liters per second

Details

single value or if zoo series - zoo object

Value

single value or if zoo series - zoo object

Author(s)

Stephen A Sefick Jr.

Examples

```
lps.cms(134000)
```

`ODobbins` *O'Conner Dobbins Surface Renewal Method for calculating Rearration Coeffiecient*

Description

calculate reaeration coefficient with the O'Conner Dobbins method

Usage

```
ODobbins(vel, dep)
```

Arguments

`vel`	velocity in m/s
`dep`	depth in meters

Details

Surface Renewal

Value

Reaeration Cofficient (single value)

Author(s)

Stephen A Sefick Jr.

References

O'Connor, D. J., and W. E. Dobbins (1958). Mechanisms of reaeration in natural streams. Transactions of American Society of Civil Engineers, 123: 641-666.

Examples

```
#velocity 0.6
#depth 0.4572
ODobbins(0.6, 0.4572)
```

---

read.production *Read in Time Series Data as zoo Object*

Description

Wrapper Function to read.zoo

Usage

```
read.production(data)
```

Arguments

data	a csv file with headers and the date as mm/dd/yyyy hh:mm:ss format (think excel spreadsheet date format and the file is saved as a csv file)

Details

This is a wrapper function to read.zoo with a specific format required see above

Value

zoo object

Author(s)

Stephen A Sefick Jr

See Also

read.table

rear.flux *Calculate Rearation Flux*

Description

Calculates Rearation Flux

Usage

```
rear.flux(DO, Ktemp, temp, interval)
```

Arguments

DO	Dissolved Oxygen mg/L
Ktemp	Temperature Corrected K (Rearation)
temp	Temperature degrees Celcius
interval	Number of readings in a day 15min = 96

Details

zoo object as input

Value

time series of rearation flux (zoo object)

Author(s)

Stephen A. Sefick Jr.

References

Bott, T.L. 1996. Primary Productivity and community respiration. In F. R. Hauer and G. A. Lamberti (ed.), Methods in stream ecology. Academic Press, Inc., New York, N.Y.

See Also

ODobbins, Kt

Examples

```
#Use vel=0.6 and depth=0.4572
data(DOTemp)
d <- ODobbins(0.6, 0.4572)
f <- rear.flux(DOTemp[,2], Kt(d, DOTemp[,1]), DOTemp[,1], 96)
plot(f)
```

simp *Numeric Integration Using Simpson's method*

Description

Numeric Integration using the Simpson Method

Usage

```
simp(y, a = NULL, b = NULL, x = NULL, n = 200)
```

Arguments

y	y values to integrate
x	x values to integrate over
a	NULL
b	NULL
n	number of divisions defaults to 200

Value

Numeric Value of the integration

Author(s)

Rolf Turner

Examples

```
# 4-x^2-y^2
fun <- function(x, y){
a <- 4
b <- x^2
d <- y^2
z <- a-b-d
return(z)
}

a <- fun(seq(-1000,1000,1), seq(-1000,1000,1))
simp(a, x=-1000:1000, n=1000)
```

`sunrise.set` *Calculate Sunrise Sunset Times*

Description

This function calculates sunrise sunset times in POSIXct and returns it in a handy dandy format to wither export as a csv file or use directly in the calculation of Stream Metabolism. This function is based on maptools which is based on the NOAA sunrise sunset claculator.

Usage

```
sunrise.set(lat, long, date, timezone = "UTC", num.days = 1)
```

Arguments

`lat`	Latitude in decimal degrees
`long`	Longitude in decimal degrees
`date`	starting date (needs to be in quotes and in the format yyyy/mm/dd)
`timezone`	Time zone set to UTC default (needs to be in quotes)
`num.days`	1 if you just want only the calculation preformed on "date" (default)

Details

Remember that the Prime Meridian is 0 through Greenwich, England. So anything W is - and anything E is +. Also anything in the Northern hemisphere is + latitude and Southern Hemisphere is - lattitude. Generally UTC+5 is Eastern Standard Time, UTC+6 is CST, UTC+7 MST, UTC+8 PST. Another way of specifying time zones is Country City see examples. Be aware of timezones and daylight and standard time when using this function!!!!!!! This will help you avoid headaches caused because minor oversites = large error in your calculations

Value

`output`	data frame with all dates sunrise and sunset times specified

Author(s)

Stephen A Sefick Jr.

References

http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html

Examples

```
#This is for Atlanta Georgia
#(Only so that you can compare it to the NOAA
#website that is given above)
sunrise.set(33.43, -84.22, "2008/01/01", timezone="UTC+5")

#Same As above but look at Time Zone Specification
sunrise.set(33.43, -84.22, "2008/01/01", timezone="America/New_York")
```

---

window.chron — *Time Windows of Diurnal Curves*

Description

Takes a time window of a larger series

Usage

```
## S3 method for class 'chron'
window(x, day1, hour1, day2, hour2, ...)
```

Arguments

`x`	data to be subsetted
`day1`	start day
`hour1`	start time
`day2`	end date
`hour2`	end time
`...`	other arguments

Value

subset by time

Author(s)

Stephen A Sefick Jr.

References

chron, window, window.zoo

See Also

`window`

Examples

```
#with real data
data(DOTemp)
d <- window.chron(DOTemp, "8/18/70", "06:00:00", "8/18/70", "20:15:00")
plot(d)
```

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